Global Distribution and Variability of Surface Skin and Surface Air Temperatures as Depicted in the AIRS Version-6 Data Set

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Background Information

The AIRS Science Team AIRS/AMSU Version-6 Data Set

AIRS is the advanced IR Sounder flying on EOS Aqua accompanied by AMSU, an advanced microwave sounder. There are 9 AIRS 15 km x 15 km Fields of View (FOV's) within a single AMSU A 45 km x 45 km Field of Regard (FOR). AIRS products include land/ocean/ice surface skin temperature T_{skin}, atmospheric temperature profile $T(p)$, water vapor profile $q(p)$, and trace gas profiles; fractional cloud cover and cloud top pressure; and Outgoing Longwave Radiation (OLR). Most level-2 (single retrieval) products are generated on an AMSU FOR, but cloud products and OLR are generated for each AIRS FOV. Successful Quality Controlled AIRS soundings are generated in up to 90% fractional cloud cover. Level-3 products are gridded separately for 1:30 AM orbits and 1:30 PM orbits on a global 1˚x 1˚ spatial grid on a daily, eight day, and monthly mean basis.

Improved AIRS Version-6 Surface Skin Parameters

AIRS Version-6 products are significantly improved over those obtained previously, especially with respect to surface skin temperature (T_{skin}) and surface air temperature ($T(p_s)$). These improvements led to the ability to conduct meaningful studies of the global distribution of the difference between surface skin temperature and surface air temperature, as observed by AIRS both 1:30 PM and 1:30 AM local time. We refer to this surface skin/air temperature difference as $\Delta T_{s,a}$. $\Delta T_{s,a}$ is a very important parameter with regard to the understanding of the sensible heat flux between the Earth's surface skin and its atmosphere.

Data Sets Used in This Study

This study used the AIRS Science Team Version-6 monthly mean level-3 data for surface skin temperature and surface air temperature, each gridded separately for 1:30 AM and 1:30 PM. Values of $\Delta T_{s,a}$ are not contained in the Version-6 data set. Data products used extend from September 2002 (the start of the data set) to August 2014. Twelve-year monthly mean climatologies were generated for each 1°x1° grid box by averaging monthly mean data for all Januaries, Februaries, etc. Similarly, we generated seasonal climatologies for each season. Separate climatologies were generated for 1:30 PM and 1:30 AM. The monthly anomaly for each grid box is the difference of the value for that month from that month's climatology, and the seasonal anomaly is the difference of the values for that season from it's climatology.

AIRS level-2 (retrieval by retrieval) and level-3 1° x 1° gridded products can be obtained at the Goddard DISC http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings.

Version-6 Generation of T_{skin} and $T(p_s)$

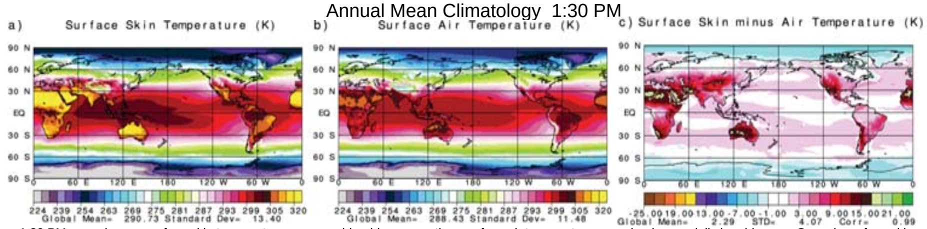
AIRS radiances are very sensitive to changes in T_{skin} , which is derived in Version-6 simultaneously with shortwave spectral emissivity $\varepsilon_{sw}(v)$, and shortwave spectral surface bi-directional reflectance $\rho_{sw}(v)$, using AIRS channels between 2396 cm^{-1} and 2665 cm^{-1}. On the other hand, AIRS radiances are not sensitive to changes in $T(p)$ very near the surface. $T(p)$ retrievals are generated by adding relatively coarse structure (≈ 2 km) changes to the initial temperature profile guess $T^0(p)$. Fine vertical structure in $T(p)$ comes primarily from the fine structure in $T^0(p)$. AIRS Version-6 generates for the first time reasonable values of $T(p_s)$ because the Version-6 Neural-Net first guess $T^0(p)$ contains very accurate low level temperature profile fine structure. This was not the case in Version-5, which used a regression guess for $T^0(p)$.

Summary

We computed level-3 values of surface skin minus surface air temperature, $\Delta T_{s,a}$, by subtracting level-3 values of $T(p_s)$ from level-3 values of T_{skin}. Level-3 values of $\Delta T_{s,a}$ appear to be of high quality with regard to both their climatology and interannual variability. We encourage researchers to study the characteristics of $\Delta T_{s,a}$ to evaluate if it is currently accurate enough for their research purposes.

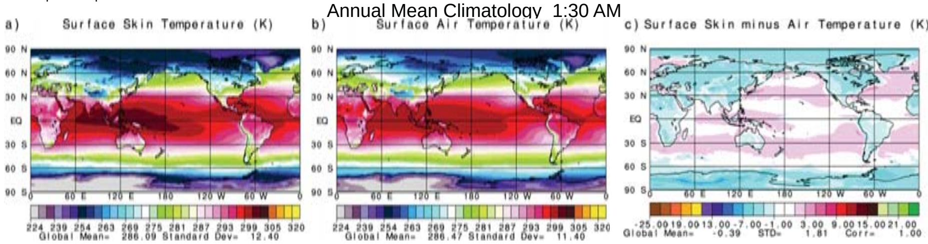
Climatologies

Annual Mean Climatology 1:30 PM



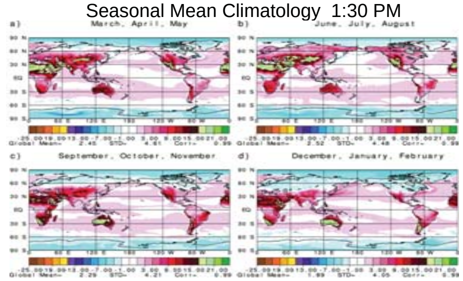
1:30 PM annual mean surface skin temperatures are considerably warmer than surface air temperatures over land, especially in arid areas. Oceanic surface skin temperatures also tend to be warmer than surface air temperatures in the mid-latitudes. Polar surface skin temperatures are colder than surface air temperatures except over open ocean.

Annual Mean Climatology 1:30 AM



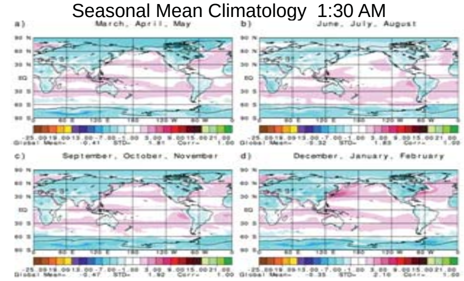
1:30 AM annual mean surface skin/surface air temperature differences are similar to those at 1:30 PM over ocean and in polar regions. Unlike at 1:30 PM, most land area surface skin temperatures are colder than surface air temperatures at 1:30 AM.

Surface Skin minus Surface Air Temperature (K) Seasonal Mean Climatology 1:30 PM



The basic patterns of 1:30 PM surface skin temperature minus surface air temperature are common in all seasons. Over land, local spring and local summer patterns are similar to each other, as are local fall and local winter patterns.

Surface Skin minus Surface Air Temperature (K) Seasonal Mean Climatology 1:30 AM



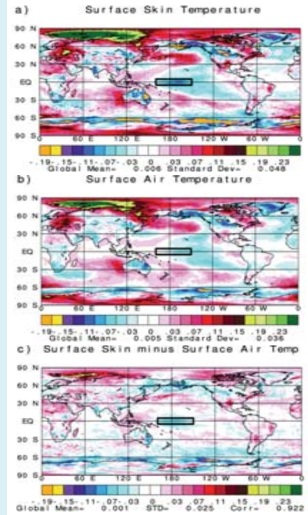
Interseasonal differences of 1:30 AM surface skin minus surface air temperatures over land are smaller than at 1:30 PM. Ocean surface skin temperatures are significantly warmer than surface air temperatures off the east coast of Asia and North America in the winter. This is a result of advection of cold air from the continents to the ocean.

Interannual Variability of Surface Skin and Surface Air Temperature Difference ($\Delta T_{s,a}$)

The figures in the panel to the right show the variability of $\Delta T_{s,a}$ in terms of the behavior of its anomaly time series, as depicted by ARCs and ENCs. The Average Rate of Change (**ARC**) of a product is the slope of the linear least squares fit to the anomaly time series. The El Niño Correlation (**ENC**) is the correlation of the anomaly time series with that of the El Niño Index (**ENI**), which is given by the NOAA Niño-4 SST minus its climatology as computed over the same 12 consecutive years. Results shown are for the average of the 1:30 AM/PM observations, as computed over the period September 2002 through August 2014.

Interannual Variability

AIRS Version-6 ARCs



ARCs of surface skin and surface air temperatures each show pronounced large scale spatial patterns which are highly correlated with each other. ARCs of surface skin temperature are generally larger than those of surface air temperature. Surface skin temperatures over the Niño 4 region, which is surrounded by a black rectangle, have cooled over the last 12 years, which started with an El Niño and ended with a La Niña. There has been considerable warming over this period of both surface skin and air temperatures at high northern latitudes, but cooling over Greenland. Global mean surface skin and surface air temperatures have both warmed at a rate of ≈0.005 K/yr over this time period.

Niño 4 region

AIRS Version-6 ENCs

Anomaly time series of surface skin and surface air temperatures are for the most part each locally highly correlated (or anti-correlated) with the El Niño Index. ENCs of surface skin temperature are similar to those of surface air temperature, but larger in magnitude. These correlations are the main cause for the patterns of ARCs computed over the time period under study. Regions with positive El Niño Correlations cooled, as the Niño 4 region did, while regions with negative El Niño Correlations warmed. Surface skin and surface air temperature anomalies in polar regions are not highly correlated with El Niño activity. ENCs of surface skin minus surface air temperature are in general small, but they exhibit a strong oscillation centered over Indonesia.